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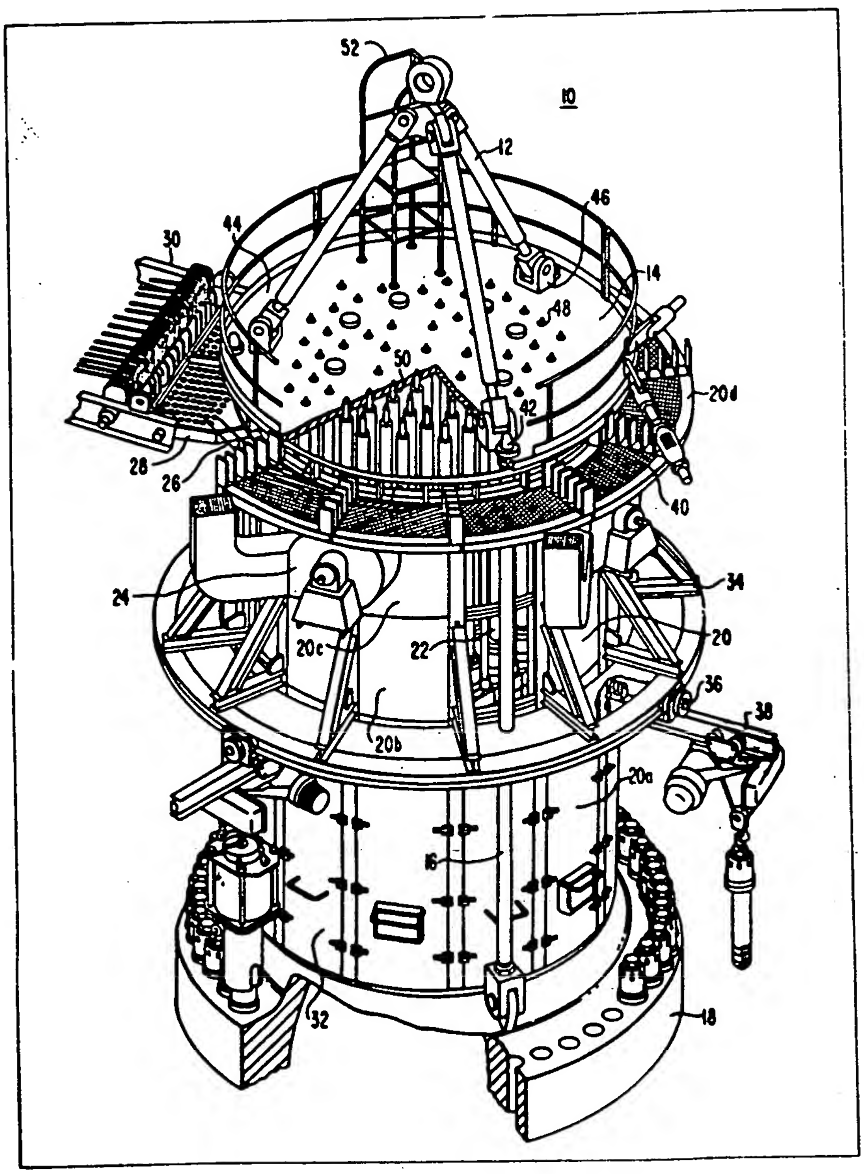
(54) **Standard integrated head package**

(57) An integrated head package for a standard-type nuclear reactor consolidating many components and subassemblies of the upper reactor structure into a single unit which may be removed from the reactor vessel in a single lift. Included among the consolidated elements are a pressure vessel head (18), a cooling shroud (20), control rod drive mechanisms (22), a missile shield (14), a lifting rig, a hoist assembly (38), and a cable tray assembly (28, 30).



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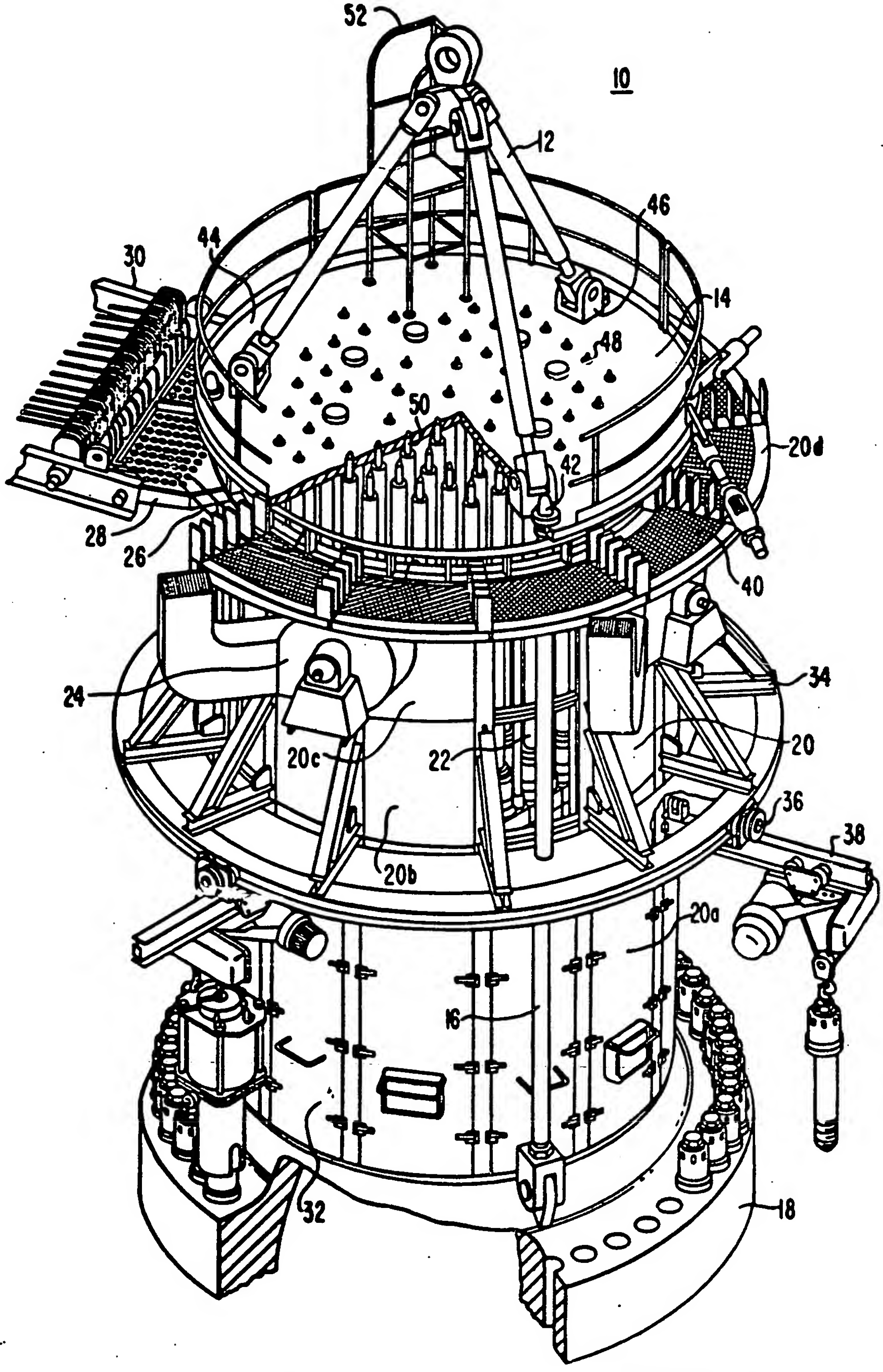
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SPECIFICATION

Standard integrated head package

This invention pertains to the preparation of a nuclear reactor for refueling, and in particular to a novel combination of features of a standard-type reactor that can help to reduce refueling times.

The term "standard-type reactor" is used herein as a reference to the type of nuclear reactor in commercial operation in the field today.

The time required for removing the upper structure from a standard-type nuclear reactor has made frequent refueling impractical. Because of the safety and structural functions performed by reactor internals, various components are assembled to each other in such a way as to insure their integrity during reactor operation. Therefore, in order to disassemble the reactor internals, each component or subassembly must be individually disconnected from another component or subassembly in sequential fashion.

This time-consuming preparation begins with disconnection of cabling which connects control rod drive mechanisms to reactor controls. After vessel head insulation has been removed, instrumentation thermocouple leads are individually disconnected. Vessel stud nuts are detensioned with a special tool, then the studs and nuts are removed from the vessel flange. Guide studs are installed in several stud holes to provide proper head alignment on reinstallation and the remainder of the stud holes are plugged. The reactor vessel head is unseated by a permanently-attached crane and slowly lifted while the reactor cavity is flooded with borated water. Once the head has been removed, the control rod drive shafts are individually unlatched from rod cluster control assemblies, which remain in the core. Finally, the upper internals and control rod drive shafts are lifted from the reactor vessel using a reactor internals lifting rig. This final lift exposes the reactor core.

The tedious disassembly procedure is reversed for reinstallation of the elements following refueling. The entire refueling process requires some three to six weeks to complete.

Evaluation of the cost, in terms of reactor downtime, of refueling a standard-type nuclear reactor provided a large economic incentive to reduce the time necessary to refuel. The ensuing effort resulted in the design of a new reactor called the rapid refueling reactor. This design, disclosed generally in U.S. Patent No. 4,158,599, involves the consolidation of all components and subassemblies of the upper structure of a nuclear reactor into a single integrated head package. The integrated head package may then be lifted with all cabling and cable supports still attached, as disclosed in U.S. Patent No. 3,836,430, to expose the core of the reactor.

U.S. Patent No. 3,836,429 discloses the consolidation of features of the upper structure of a nuclear reactor to embody the integrated head package of the rapid refueling reactor. During refueling, all components and subassemblies which were individually detached from the reactor vessel of the standard-type reactor remain fixedly attached to the vessel closure head of the rapid refueling reactor. These components and subassemblies include all cabling, all components associated with the upper internals package, such as upper support plate, support columns and upper core plate, control rod drive mechanisms and the control rod drive shafts. The control rod clusters are also removed as a part of the integrated head package of the rapid refueling design.

The rapid refueling reactor involves significant structural alterations to the design of the standard-type reactor in order to facilitate attachment of the upper internals package to the vessel closure head in a structurally sufficient manner. As a result, the rapid refueling reactor cannot be implemented as a retrofit of existing standard-type reactors. Hence, a significant problem associated with lengthy refueling times still exists as to standard-type reactors in operation and currently under construction.

Accordingly, it is the principal object of the present invention to provide a head package for a reactor structure which permits both rapid refueling and implementation with the standard-type reactor structure.

With this object in view, the present invention resides in an integrated reactor head package for decreasing the time required to disassemble and reassemble a standard-type reactor vessel during refueling operations, said head package consisting of an integrated arrangement of a pressure vessel closure head for sealingly closing a reactor vessel, control rod drive mechanisms for controlling position of control rod clusters within a reactor core, a cooling shroud for enclosing the control rod drive mechanisms and for retaining cooling environment therein, a missile shield for providing lateral support to said control rod drive mechanisms and for preventing ejection of said control rod drive mechanisms, means for attaching a lifting crane to said head package for lifting said head package onto and off of the reactor vessel, a plurality of vertical lifting rods linking said lifting crane attaching means with said closure head for providing structural support to said head package, a plurality of hoist assemblies for handling stud tensioner tools and stud removal tools, means for supporting said hoist assemblies, a plurality of cooling fans attached to said cooling shroud for directing flow of cooling air within said cooling shroud, a cable tray assembly for supporting cables routed between said head package and an operating floor, which cable tray assembly is rapidly detachable from said head package, said assembly including a connector plate for facilitating rapid detachment of said cable tray assembly from said head package, and a tray for supporting the cable between said connector plate and points of penetration into said cooling shroud.

With the arrangement according to the present invention, the time required to refuel a standard-type reactor is substantially reduced by the employment of an integrated head package which consolidates many of the components and subassemblies of the upper reactor structure and which may be removed from the reactor vessels in a single lift.

The invention will become more readily apparent

from the following description of a preferred embodiment thereof shown, by way of example only, in the accompanying drawings, in which the single Figure shows a perspective view of the invention with a cutaway in appropriate places to reveal detail.

The basic operational reactor components embraced by this invention are a pressure vessel head with control rod drive mechanisms, a lifting rig, a missile shield, lifting rods, a cooling shroud, cable tray and cabling, cooling fans, an operator stand, and hoist assemblies. Detailed description of the structure and function of these components exists in the prior art and will not be undertaken here. The discussion below is directed to a combination of these components resulting in an improved integrated head package for the standard-type reactor. It should be noted at the outset that this invention, embodied as a standard integrated head package, does not embrace an upper internals package or control rod assemblies as does the head package of the previously referenced rapid refueling reactor, because the addition of these subassemblies would necessitate major structural alterations to the standard-type reactor vessel.

The Figure depicts a standard integrated head package. A three-legged head lifting rig 12 is pin-connected to a missile shield assembly 14. The missile shield assembly 14 is supported on three lift rods 16 that attach to a reactor vessel head 18. The missile shield assembly 14 is generally a heavy reinforced plate of steel for restraining and intercepting a control rod drive housing in the event of a major problem.

A cooling shroud 20 is mounted directly to a top of the head and surrounds control rod drive mechanisms 22 which control movement of the control rod clusters into and out of the core. The cooling shroud 20 provides a major support structure for the head package as well as defining an enclosure which provides a cooling environment for the control rod drive mechanisms 22. Cooling fans 24 mount directly to the cooling shroud 20. Lift rods 16 are tied into the cooling shroud 20 to provide additional rigidity to the structure and to [illegible] lifting load from the missile shield 14 to the vessel head 18. Cabling 26 is routed from the top of the control rod drive mechanisms 22 around the top of the standard integrated head package 10 to a connector plate 28 on the side of the structure. From the connector plate 28, the cabling is routed along a cable tray 30 to the respective cable terminations.

The cable tray 30 is shorter than the cable tray of the rapid refueling reactor so as to conform to the particular geometry of the standard-type reactor plants. The cable tray is supported at the reactor end on the cooling shroud 20 and at the other end on supports on a steam generator wall (not shown). As part of the refueling operations, the cabling 26 is disconnected at the connector plate 28 and stored on the cable tray 30. The cable tray 30 can then be pivoted at the operating floor end to a storage position apart from the reactor vessel. This arrangement differs from the cable tray arrangement of the rapid refueling reactor, where the layout within containment permits the cable tray to remain attached to the head structure during refueling.

The cooling shroud 20 is made in four sections that bolt together as opposed to three sections on the rapid refueling design. A lower shroud 20a, or first section, bolts directly to the top of the vessel head 18. The lower shroud 20a comprises a plurality of doors 32 permitting maintenance access to the vessel head insulation and instrumentation thermocouple columns (not shown). The lower shroud 20a also supports baffling (not shown) which surrounds the control rod drive mechanisms 22 and is used to direct the flow of cooling air.

A middle shroud 20b bolts to the top of the lower shroud 20a. This section supports baffling as well as hoist supports 34. The hoist supports 34 comprise two tracks circulating the perimeter of the middle shroud 20b. An outer track supports the main trolleys 36 on the hoist assemblies 38. An inner track is used as a counterbalance support for the hoist assemblies 38. The hoist assemblies 38 are used to maneuver stud tensioner tools and stud removal tools during refueling activities.

An upper shroud 20c bolts to the top of the middle shroud 20b and supports baffling (not shown) and a plurality of control rod drive mechanism cooling fans 24. The cooling fans 24 circulate air within the shroud 20 to transfer waste heat from the control rod drive mechanisms 22.

A messenger tray assembly 20d, which encircles the perimeter of the upper shroud 20c, is used to support control rod drive mechanism power and instrumentation cabling 26. Cabling from the control rod drive mechanisms 22 and from thermocouples (not shown), passes along wire supports (not shown) to the messenger tray assembly 20d. All cablings converges at a connector plate 28 which links the cable tray 30 to the messenger tray assembly 20d. The use of the messenger tray assembly 20d and connector plate 28 facilitates rapid disconnection and reconnection of the cable tray from the integrated head package, a procedure which is unnecessary for the rapid refueling reactor.

The three vertical lifting rods 16 pin-attach to the vessel head 18 and are attached to the cooling shroud 20 at two locations along their length. The lifting rods 16 serve to translate a lifting force applied by a crane from the missile shield assembly 14 to the vessel head 18. The lifting rods 16 are permitted to move vertically, relative to the shroud 20, but are restrained from horizontal movement. A bullet nose is machined at a top end 42 of the lifting rods 16 to provide guidance when lowering the missile shield assembly 14 onto the lifting rods 16.

The missile shield assembly 14 comprises a circular flat plate 44 which is bolted to the lift lugs 46, which pin-attach to the lifting rig 12. The flat plate 44 is punctuated by a plurality of chamfered holes 48 to permit protrusion of the control rod drive mechanism housing extensions 50 therethrough. This arrangement provides lateral support to the control rod drive mechanisms 22 and prevents any part of the mechanism 22 from penetrating the containment housing (not shown) in the event of a major break. The holes [illegible] the missile shield assembly 14 of the invention [illegible] chamfered to facilitate the process of

installation. The bolted flat-plate design of the missile shield assembly 14 of the integrated head package 10 differs from the welded egg-crate pattern of the missile shield in the prior art. The bolted flat-plate design improves the manufacturability of the assembly 14, provides a safer and more convenient operator working surface, and eliminates certain requirements applicable to weldments (American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III).

An operator stand 52, bolted directly to the missile shield plate 44, provides safe and convenient access to the eye of the lifting rig 12 for connection of the polar crane hook (not shown) thereto.

Thus, the standard integrated head package provides in a neat, compact design, a system that reduces reactor downtime and decreases manpower requirements by reducing the number of operations required to assemble and disassemble the standard reactor vessel during refueling.

CLAIMS

1. An integrated reactor head package for decreasing the time required to disassemble and reassemble a standard-type reactor vessel during refueling operations, said head package being characterized by an integrated arrangement of a pressure vessel closure head (18) for sealingly closing a reactor vessel, control rod drive mechanisms (22) for controlling position of control rod clusters within a reactor core, a cooling shroud (20) for enclosing the control rod drive mechanisms (22) and for retaining cooling environment therein, a missile shield (14) for providing lateral support to said control rod drive mechanisms (22) and for preventing ejection of said control rod drive mechanisms (22), means (12) for attaching a lifting crane to said head package for lifting said head package onto and off of the reactor vessel, a plurality of vertical lifting rods (16) linking said lifting crane attaching means with said closure head (18) for providing structural support to said head package, a plurality of hoist assemblies (38) for handling stud tensioner tools and stud removal tools, means (34, 36) for supporting said hoist assemblies (38), a plurality of cooling fans (24) attached to said cooling shroud for directing flow of cooling air within said cooling shroud (20), a cable tray assembly (28, 30) for supporting cables routed between said head package and an operating floor, which cable tray assembly (28, 30) is rapidly detachable from said head package, said assembly including a connector plate (28) for facilitating rapid detachment of said cable tray assembly (28, 30) from said head package, and a tray (30) for supporting the cable between said connector plate and points of penetration into said cooling shroud.

2. A reactor head package according to claim 1, wherein said cooling shroud (20) comprises a plurality of sections (20a, b, c) which stack one on top of the other and bolted together, and wherein a lower section (20a) of said cooling shroud (20) comprises a plurality of doors providing maintenance access to interior apparatus.

3. A reactor head package according to claim 1 or 2, characterized in that said missile shield (14) comprises a flat plate having a plurality of chamfered holes to facilitate installation of said missile shield over said control rod drive mechanisms, and wherein said missile shield is a top for an enclosure formed by said cooling shroud.

4. A reactor head package according to claim 1, 2 or 3, characterized in that said means (12) for attaching a lifting crane to said head package comprises a tripod lifting rig attached to said missile shield (14), said lifting rig having an eye at a peak of said tripod for accepting a hook from the lifting crane.

5. A reactor head package according to any of claims 1 to 4, characterized in that said vertical lifting rods (16) have a bullet shaped nose (42) at an upper end facilitating installation of said missile shield (14) thereon.

6. A reactor head package according to any of claims 1 to 5, characterized in that said means (34, 36) for supporting said hoist assemblies (38) comprises two concentric tracks circulating the perimeter of said cooling shroud (20) and being attached thereto.

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